

AOSN MURI: A COLLABORATION FOR AUTONOMOUS OCEANOGRAPHIC OBSERVATIONS

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LONG TERM GOAL

To create and demonstrate a reactive survey system, capable of long-term unattended deployments in harsh environments. We refer to such a system as an Autonomous Ocean Sampling Network (AOSN). The goal of this part of the larger effort is to develop the capabilities of inexpensive autonomous vehicles to observe the ocean over months and thousands of kilometers.

OBJECTIVE

The objective of the project to develop an autonomous underwater vehicle capable of economical long-term operation while maintaining station or carrying out simple surveys and reporting results to, and receiving instructions from, satellite.

APPROACH

This project is the Scripps Institution of Oceanography's (SIO) component of a collaboration with the Woods Hole Oceanographic Institution (WHOI) and the Webb Research Corporation (WRC). Our approach is to develop a glider, propelled by buoyancy change and lifting wings, based on the capabilities of the Autonomous Lagrangian Circulation Explorer (ALACE). The ALACE is a subsurface float that periodically increases its buoyancy in order to surface for satellite relay and then returns to depth. We are adapting ALACE technology to develop an electric powered, winged, underwater glider capable of long-term autonomous operation while sustaining average forward velocities of 20 to 30 kilometers per day.

In the original plan for collaboration, WRC was responsible for construction of the vehicle and actuators to move internal ballast for flight control. SIO was responsible for the system controller, control algorithms, selection of flight-control and scientific instruments and integration into a field-ready instrument. WHOI was to provide overall coordination, develop two-way satellite communication techniques and coordinate field testing of the completed system. After inspection of first vehicle delivered by WRC this plan was modified so that SIO would design a new vehicle.

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WORK COMPLETED

In the previous year a flight simulator program was developed and used to establish the general parameters required for efficient flight and flexible control. Early this year, a central controller microprocessor was selected and interfaced to sensors for vehicle attitude, depth and heading and to a multiplexing 16-bit A/D suitable for temperature and conductivity measurements.

After inspection of the WRC prototype received October 1996 a complete redesign was implemented with the goals of reducing hydrodynamic drag, developing a hydraulic pump that would function safely with gas dissolved in the hydraulic fluid, increasing the safe operating depth below a few hundred meters, providing ballast-moving actuators with adequate range of movement for full control, designing external hydraulic bladders that would not fail if emptied under high pressure, allowing the vehicle to be trimmed for normal flight with a full payload of batteries, and providing connections to external sensors and antennas.

The thorough redesign began with hydrodynamic drag tests of a few plausible hull shapes. A streamlined aluminum hull was then constructed using a modern computer-controlled machining. Suitable ports for connecting antennas, external sensors and hydraulic bladders were provided as were ballast-moving actuators capable of a full control range. Taking advantage of proprietary commercial processes, external bladders with suitable anti-extrusion protection over the inlets were manufactured. At the end of FY97 we have achieved all the design objectives and the subsystems have been assembled. The prototype will be tested in the laboratory, a nearby lake and at sea before it is delivered to WHOI for installation of navigation and communication systems and operational testing.

RESULTS

Low hydrodynamic drag is essential to the general design concept because adequate speed at minimum power expenditure is essential even to maintain station and even more important for other missions. Tow tests of half-scale and full-scale models of vehicle hulls indicated that, for anticipated vehicle size and operating speeds of 20-30 cm/s, conventional bluff-body forms could have drags comparable to sophisticated laminar-flow forms, although at higher speeds laminar-flow shapes are substantially better. By adjusting slenderness and the shape of the forward portion of the hull, good hydrodynamic performance was achieved with a shape that permits a conventional pressure case to serve as the hydrodynamic hull. No external shroud, that could capture air while at the surface, is required. At speeds between 20 and 30 cm/s, a full-scale 2-m hull of this design has approximately 50% the drag of the WRC design.

There are few commercial hydraulic pumps with the small size, high energy efficiency and high pressure rating required for this vehicle. By redesigning a commercial well-logging model we have succeeded in developing a pump with these requirements that does not fail if there are small bubbles in the hydraulic fluid. The prototypes show comparable efficiency to the best of commercial pumps and are substantially more reliable under real-world conditions.

IMPACTS/APPLICATIONS

The capability of proliferating observations in autonomous or remotely controlled vehicles of this sort should be valuable in both scientific circumstances, where numerous observations are needed to detect desired signals in the presence of other phenomena, and in operational circumstances where inexpensive sensors in unmanned vehicles are desirable.

TRANSITIONS

None.

RELATED PROJECTS

This project is part of the Multidisciplinary University Research Initiative: "Real-Time Oceanography with Autonomous Ocean Sampling Networks: A Center for Excellence." It is closely linked to the companion project by Breck Owens of Woods Hole Oceanographic Institution.